NATIONAL BUREAU OF STANDARDS

Technical News

BULLETIN

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Contents

COVER: Particles of bone char ($\times$ 40), a solid adsorbent made by pyrolizing animal bones. About 2 million tons of bone char are used each year in purifying and decolorizing sugar. The National Bureau of Standards has, since 1939, been conducting a long-range cooperative research program, under the sponsorship of the Bone Char Research Project, Inc., to increase understanding of the fundamental nature of bone char and other solid adsorbents. (See p. 94.)

Radioactive Fallout Predictor

AN IMPROVED radioactive fallout predictor developed at the Bureau computes the fallout expected from a single blast of known characteristics, if the burst location and wind speeds and directions are known. This equipment was developed for the U.S. Army Signal Corps by J. H. Wright of the data processing systems laboratory.

The fallout predictor has been designed specifically for single-purpose field use; its specialized design has made it lightweight, portable, and simple to operate. These features make it a low-cost equipment that can be operated without need of any specialized knowledge or manual skill.

The machine supplies as its output a panel meter indication of the total fallout or of fallout rate at a selected time, predicted for a point manually selected on a standard Army map. Simultaneously, it provides an oscilloscopic presentation of fallout distribution for qualitative appraisals. Less than 5 sec are required to compute a prediction that is valid for any selected point within a 300-mile radius of the burst location and during the first 30 hr following the explosion.

Fallout Prediction

In the development of radioactive devices, fallout prediction has been necessary to prevent test detonations that would produce hazardous fallout distributions. Alterations in predicted fallout patterns resulting from wind changes have in many cases necessitated delaying tests, sometimes repeatedly. Such decisions were made on the basis of fallout predicted by a team of scientists in a half-hour computation. Use of a general-purpose digital computer reduced the time required by about half, but a large, expensive machine and the team of experts were still needed. The fallout prediction machine was developed to replace them and speed the computation.

Both military and civilian authorities will need knowledge of the radioactivity expected in fallout following the explosion of a nuclear weapon, the former to plan military operations and the latter to plan evacuation routes and points. They will need to know the location, time, and intensity of radioactive fallout.

A fallout prediction system for field use will fill some information needs better than would large-area information from a central computing system—if available. Following a radioactive blast the immediate need will be for a quick, locally related fallout prediction, analogous to a local weather report, "a half-inch

of rain will fall in counties north of the city by 10 p.m.," as opposed to a wide-area prediction.

For local fallout predictions to be generally available, a fallout predictor must be cheap enough to be easily obtained, portable enough to be easily installed and relocated if necessary, and simple enough to be operated without need for any computer knowledge. The input requirements should be modest and easily met.

Earlier Fallout Predictor

An analog fallout predictor designed at NBS in 1956 for the Weather Bureau and the Atomic Energy Commission [1] performed computations in a fraction of a second to produce a map-type display of the predicted fallout radioactivity on a 21-in. oscilloscope screen. The electro-optical characteristics of the oscilloscope tube were used in the computation, producing a striking presentation but also limiting the accuracy of the device.

The earlier fallout predictor was considered to be portable, being housed in two racks and a cabinet. For inputs it required wind speed and direction figures for 20 strata, as well as a description of the radioactive cloud, to be set into its front-panel controls. Unskilled personnel could operate it fairly easily. The operator merely set input dials and then appraised the radioactivity prediction (total or rate) on the basis of rela-
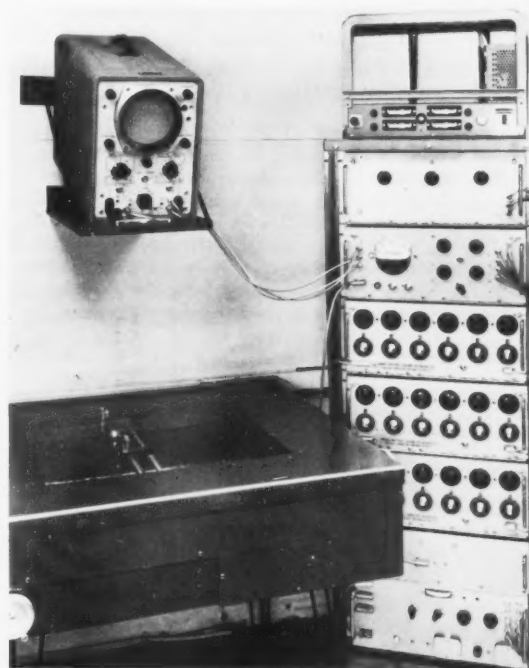
Overall view of radioactive fallout predictor shows console (*right*) with separate power supply on top, oscilloscope (*above, left*) to indicate fallout distribution, and map table for selection of points for which to make prediction. Handwheel at extreme left of map table is one of two handwheels for positioning light beam (seen near center of glass top) to position desired on map above it.

tive luminance of points on the oscilloscope display; he could also record his appraisal on a transparent map overlay placed on the oscilloscope face.

New Fallout Predictor

The fallout predictor designed under the recent Signal Corps-supported program solves the same problems as the earlier machine produced for the Weather Bureau and the AEC, but uses different techniques. These provide greater accuracy and direct electrical outputs to indicate fallout intensity and location, but for absolute rather than relative altitude settings and without requiring any specific skill of the operator.

The present equipment consists of a rack-type cabinet, a map table, a small power supply unit, and, optionally, a small oscilloscope. A new computing layout using some electromechanical computation techniques has been developed, but the same variables are controlled by panel adjustments as in the previous machine. Special transistor interval-logic circuits have been developed for some of the new computing functions. These perform an unusual task of very high speed integration of the total percentage of time spent by a function $f(x,y)$ within a small selected area $\Delta x \, \Delta y$ during many (from a few dozen to a few thousand) rapid incursions of a few microseconds each into that area.

The point for which the meter indicates predicted fallout is identified by a spot of light projected up through the glass top of the map table. In normal operation the operator selects the point by placing the appropriate map on the glass top with the burst point at the table's center and operating the map table handwheels to move the light spot to the map point desired.
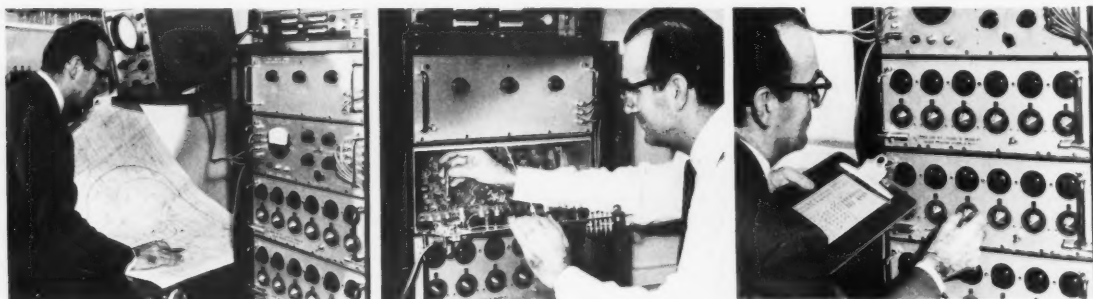
Variables of Radioactive Cloud

The predictor performs its computations by integrating the fallout, at each point selected, of radioactive particles of various sizes which originate at various parts of the cloud produced by the burst. The classes of particle size (each with its own rate of fall) and the distribution of the particles in the clouds are given by a cloud model. A three-dimensional analog function generator is required for this, using variables supplied by semipermanent adjustments of small potentiometers on six plug-in printed-circuit cards. The predictor permits instant selection of one of two such sets of cards; the adjustments of these two banks of cards are preset for the two models, but are also easily accessible for changes necessitated by new knowledge or use of a new theory. Still another cloud model can be obtained by making the appropriate adjustments on the plug-in cards while in the machine or by substituting in place of one of the original banks of six cards a set of cards preset for the desired model.

For computation of the prediction, the computer requires the following additional radioactivity source data to be set into its front panel adjustments: Total radioactivity of the cloud (in megatons or in megacuries), cloud height (in feet), cap diameter (in miles), and the cloud stem dimensions given as percentages of the cloud height and cap diameter.

Post-Burst Variables

The fallout meter reading predicts the total dose radioactivity level in roentgens (r) for the point selected, or the dose rate in roentgens per hour (r/hr) at the place and time (1 to 30 hr) selected. Predic-

Left: J. Howard Wright removes map, on which he has marked isoroentgens of predicted fallout, from top of map table. Values set into panel controls of computer are for wind speed and direction at different levels and for characteristics of radioactive cloud. Level of fallout predicted for each point selected by map-table handwheels is given by panel meter shown on console, while oscilloscope shows the area-wide distribution of fallout. *Center:* Wright sets the wind direction at one of the 18 different levels into fallout predictor. Wind-speed setting is immediately above wind direction setting for same level. *Right:* Wright makes an adjustment behind a panel of the fallout predictor. The cabinet has been designed for light weight (230 lb.), portability (extended sides of cabinet protect controls), and ease of access (wiring faces out and transistors plug into full-width subchassis). Panel meter mounted on left of dropped panel indicates roentgens of fallout predicted by computation.

Cloud-model chassis of radioactive fallout predictor permits selection from two models of radioactive cloud types. The adjustments on the six printed-circuit cards for each model, one at the left center, the other at right center, are preset to simulate theoretical or known cloud structures. The available selection of cloud models can be changed by readjustment of the semi-fixed controls or by replacing one bank of six cards by a bank preset for the desired new cloud model.
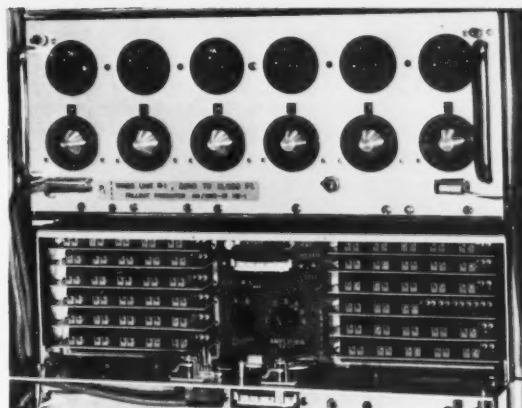
tion of dose rate for various times at the same points adds another dimension to the prediction.

Other data required for prediction computation are figures for wind speed (0 to 200 mph) and direction (0 to 360°). These data are set into the predictor program by means of continuously adjustable panel controls for each of the 18 standard artillery altitude intervals (from 0 to 1500 ft to 84,000 to 96,000 ft). The data set into the machine can be altered at any time to conform to corrected or new information, but the change is not reflected in the reading until after the first full computation cycle following.

Presentation of Prediction

The computer can be set for use with standard artillery maps of three scales, 1:1,000,000, 1:500,000, and 1:250,000; in operation the map selected is positioned north-to-north with the burst point above a pair of crosshairs in the map-table top. Measurement points within a 330-mile square can be selected without use of the map coordinates by operation of the handwheels and within a 500-mile square by use of front-panel controls. The map-table burst point can be offset 500 miles in any direction by front panel controls when desired, as when making predictions for lopsided fallout patterns.

When all necessary data are set into the predictor the radioactivity prediction at the point selected is indicated briefly by the fallout meter and the decimal multiplier for the energy level of the blast. The predictions obtained in this manner can be written on the map at the corresponding measurement points, if desired.

Use of Fallout Predictor

The fundamental philosophy in the design of this fallout predictor has been to select from a wide variety of computing devices those best adapted to solving this problem, thereby achieving very high computing efficiency while minimizing cost and size of the equipment. This concept makes best use of the man attending the machine to eliminate unnecessary servo systems, yet requiring no special human skills. The approximations in formulation of the problem are the customary ones considered to be practical limitations.

The equipment is intended for predicting fallout from a cloud represented by an "untilted" model and originating from a single blast. Post-blast factors which have been ignored are vertical winds, variation in wind patterns in time and space, cloud divergence and mixing, rain washout, and terrain effects. It has been considered impractical to deal with these factors because of the lack of input data and the enormous complications (or added solution time) that would result.

The assumptions and simplifications used have made it possible to design an analog computing machine that is well adapted to a single application—predicting radioactive fallout in the field. The entire system is compact and portable, since even the largest unit (the rack cabinet) weighs only 230 lb and is designed to be self-crating. All components can be carried in a station wagon for setting up at any locality at which 110-v a-c, 60-c/s power at 1 kw is available. Maintenance is facilitated by use of hinged panels for access to components and commercially available modular plug-in stages. No meteorological or computer experience is required of the operator. Only a power supply and the input information are needed to put the fallout predictor in operation.

[1] Radioactive fallout computer, NBS Tech. News Bull. **40**, 56 (Apr. 1956).

Radio Standards Laboratory Reorganized

THE RADIO STANDARDS Laboratory at the NBS Boulder Laboratories has been divided into a Radio Physics Division and a Circuit Standards Division to provide unified direction for a growing program. The move is designed to increase the efficiency of the laboratory's efforts to meet the space-age needs of the electronic industry.

John M. Richardson will continue to head the Radio Standards Laboratory, which is responsible for providing the central basis for the complete, consistent, uniform, and accurate measurement of physical quantities pertaining to radio science, and assurance of international coordination of such measurements.

Dr. Richardson, a member of the NBS staff since 1952, has been Chief of the Radio Standards Division since June 1960.

His work at the Bureau has been in microwave physics—including microwave spectroscopy, microwave interferometry, and physics of ionized gases—especially as these fields have bearing on standards and physical constants.

Yardley Beers, Chief of the Radio Physics Division, will direct research concerning the interaction of electromagnetic fields with matter having possible application to radio standards, frequency standards, time scales, atomic and aggregate properties of matter, and constants of physics. The division will also develop certain national standards and direct the dissemination and international coordination of the results.

Dr. Beers served as an NBS consultant in atomic frequency and time standards for several months during 1960. In October of 1961 he was appointed Chief of the Millimeter-Wave Research Section of the Radio Standards Laboratory. His special fields of research interest are: nuclear physics, microwave spectroscopy, and the electronics connected with these areas.

The Circuit Standards Division, headed by George E. Schafer, will conduct research and develop national standards of physical quantities pertaining to radio circuits and measurement techniques; disseminate the standards, especially by calibration services; and direct their international coordination.

Since he came to the Bureau in 1951, Dr. Schafer has improved existing standards of microwave attenuation, provided detailed instructions on the setting up of a calibration service for attenuators, originated a method of measuring the directivity of directional couplers which is presently being used by NBS, and made a basic study of microwave phase shift measurements which formed the basis for a new calibration service. His origination of the modulated subcarrier techniques of microwave attenuation and microwave phase shift measurements is considered an outstanding contribution to the art.

Richardson   **Beers**   **Shafer**

Changes in Schedule for NBS Radio Station WWVH

THE BUREAU has made minor changes in the broadcast schedule for radio station WWVH in Maui, Hawaii. The changes became effective July 1, 1962. They were requested by the National Aeronautics and Space Administration and are not expected to interfere with other users of the transmissions from WWVH.

The present transmission schedule of WWV, Beltsville, Maryland, will be retained, including the hourly silent period from 45 to 49 minutes past each hour. Thus the time signals of either station may be received four minutes out of each hour without interference from the other. A change in the transmission of the binary time code from station WWV has been made so that the amplitude between pulses on the 1 kc/s subcarrier are about one-third of full amplitude instead of going to zero.

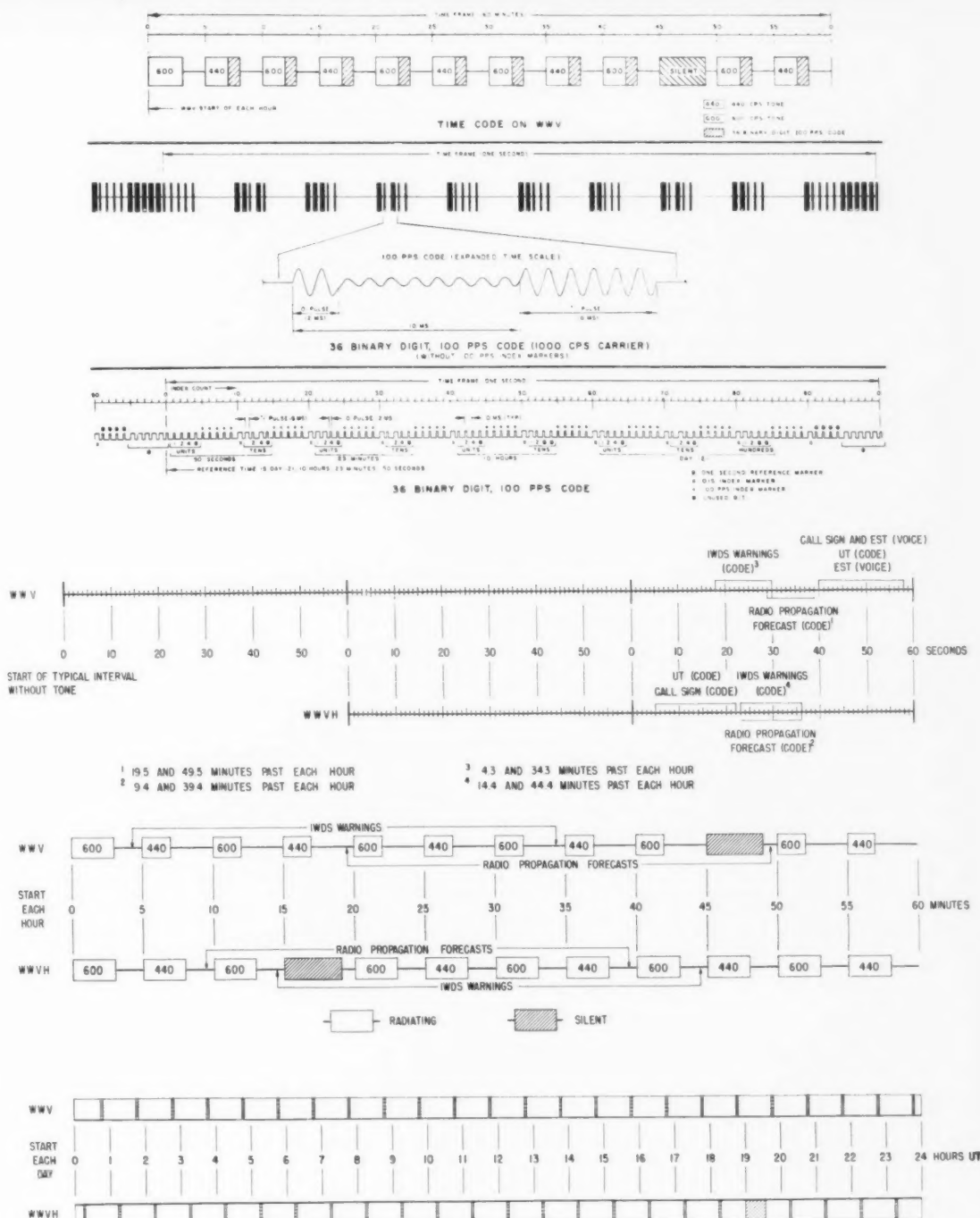|	
Previous Schedule	*Revised Schedule*
Continuous except for four 3-minute silent periods each hour, the first commencing on the hour and the other 3 on each quarter hour thereafter, and a 34-minute silent period each day at 1900 UT.	Continuous except for one hourly silent period from 15 minutes to 19 minutes past each hour and a 34-minute silent period at 1900 UT.

TIME CODE ON WWV

36 BINARY DIGIT, 100 PPS CODE (1000 CPS CARRIER)
(WITHOUT DC PPS INDEX MARKERS)

36 BINARY DIGIT, 100 PPS CODE

1 19.5 AND 49.5 MINUTES PAST EACH HOUR
2 9.4 AND 39.4 MINUTES PAST EACH HOUR

3 4.3 AND 34.3 MINUTES PAST EACH HOUR
4 14.4 AND 44.4 MINUTES PAST EACH HOUR

RADIATING   SILENT

*REVISED FIGURE 2 NBS MISC. PUBL. 236

McPherson Named To Head
Inter-American Program

Archibald T. McPherson, NBS Associate Director, has been named by Secretary of Commerce Luther H. Hodges to head the Department's new program of cooperation with Latin American nations in establishing standards for their raw materials and manufactured goods that enter into inter-American commerce and trade.

The Department will work closely with the recently organized Pan-American Standards Committee in their effort to set up a framework of standards governing quality, varieties, testing methods, and other variables for ten major categories of commodities.

The original impetus for Pan-American standards came from the Ministers of Finance or Economy of the American Republics who saw that standards for the raw and manufactured goods which they produced were a basic necessity for the development of their economies. In the United States, the Federal and state governments and several hundred scientific and technical societies have spent millions of man hours and large sums of money in developing the standards, codes, and specifications on which our industrial economy is based.

The new program will make this experience available to the Latin American countries, thereby facilitating the development of standards which will enable Latin American products to be supplied in a form more useful to U.S. industry and consumers. At the same time, adequate Pan-American standards for manufactured items will be advantageous to the United States by enabling producers of exported products to meet the requirements of the Latin American market, which are often quite different from those of our domestic market.

The countries that now hold membership in the Pan-American Standards Committee are Argentina, Brazil, Chile, Colombia, Mexico, Peru, the United States, Uruguay, and Venezuela. The United States member is the American Standards Association, a nongovernmental agency which has served for many years in the field of national and international standards.

Dr. McPherson has been responsible for codes, specifications, test methods, and international standards for industrial materials at the Bureau. A 1918 appointee to the NBS staff, Dr. McPherson has also served as chief of the NBS Rubber Section, and head of the Division of Organic and Fibrous Materials. He became an associate director of the Bureau in 1951. Long active in various professional societies, Dr. McPherson is a past president of the Washington Academy of Sciences. His career at the Bureau has included work in the fields of gas chemistry, electrical insulation, natural and synthetic rubber, and high polymers.

Articles by NBS Authors in 1960 URSI Proceedings

Five of the 27 articles in *Monograph of Radio-electric Measurements and Standards, XIII General Assembly of URSI, London, 1960* (117 pages),[1] edited by B. Decaux, are by NBS authors:

The cesium resonators of the National Bureau of Standards, J. M. Richardson;

Synchronization of time standards for satellite tracking, P. L. Bender;

Electronic quantities for international standardization, M. C. Selby;

Report on the velocity of light, J. M. Richardson; and

Proton gyromagnetic ratio, P. L. Bender.

Extensive United States contributions to the work of URSI during 1960 can be found in one complete issue of the *NBS Journal of Research, Section D, Radio Propagation.*[2]

[1] *Elsevier Publ. Co., Amsterdam, The Netherlands, Dec. 1961; van Nostrand Co., Princeton, N.J. (U.S. distribution).*
[2] *J. Research NBS* **64D** *(Radio Prop.) No.* **6** *(Nov.–Dec. 1960).*
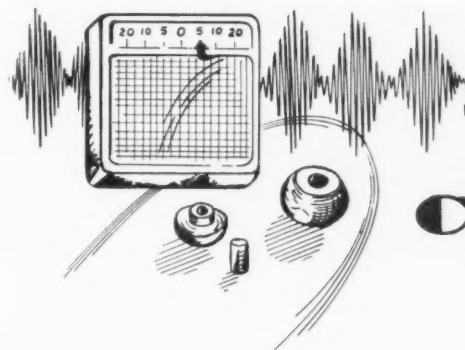
STANDARDS AND CALIBRATION

Vacuum Ultraviolet Wavelength Standards To Be Developed

The development of techniques for gathering solar and stellar vacuum ultraviolet data with satellite-borne instruments has increased the need for precise laboratory data necessary for the interpretation of the collected spectra. To meet this need the Bureau, under the sponsorship of the National Aeronautics and Space Administration, is preparing for the installation, sometime in July, of a vacuum ultraviolet spectrograph and scanning monochromator. This device will be used to establish reliable wavelength standards in the vacuum ultraviolet region (500 to 2000 A); other projects will include classification of spectra, determination of ionization potentials, and the measurement of line intensities, line shapes, and transition probabilities. These programs will be directed by Victor Kaufman of the Spectroscopy Section.

The spectrograph will have a concave grating with a 35-ft radius of curvature, and a ruled area (1200 lines/mm) of 100×175 mm. Gratings are readily interchangeable, as are both entrance and exit slits. During operation, pressure in the system will be held to 10^{-5} mm Hg or below. Spectra will be recorded either photoelectrically or photographically; photographic plates will cover about 900 A in the first-order spectrum.

Standards Laboratory Management Workshops

The National Conference of Standards Laboratories held a series of three Standards Laboratory Management Workshops at the National Bureau of Standards April 16–18. These workshops, attended by over 60 representatives of industrial and military standards groups, provided registrants with the opportunity to present and discuss information and problems connected with standards laboratory operations. The titles of the workshops—Calibration Procedures, Techniques, and Specifications, Reliability of Measurement Standards and Instruments, and Calibration Cost Reduction and Value Analysis—give an indication of the range of topics covered.

A Standards Laboratory Conference will be held by the NCSL at the Bureau's Boulder (Colo.) Laboratories, August 8–10. The purpose of this Conference is to provide a medium for disseminating information on the organization and operation of standards labs with the goal of promoting increased competence, better organization, and uniform practices among the Nation's standards laboratories.

BONE CHAR, the product of pyrolysis of animal bones, has been used as a refining agent for sugar since 1828. Its ability to adsorb the nonsucrose impurities present in raw sugar, and to be regenerated for repeated use, makes it an effective and practical substance for purifying and decolorizing sugar.

Each year in the United States about 2 million tons of bone char—one-third the total weight of raw sugar refined yearly—is required in the refining process.[3] Actually, of course, such a large quantity of char need not be in existence at any one time because the char is continually being revivified and a mixture of new and regenerated char used in refining. Nevertheless, the char's adsorptive properties are gradually exhausted with use, so that the behavior of the mixture is not always predictable. Analysis and interpretation of the reactions that occur in revivification are thus of great practical value to the sugar industry.

To increase understanding of the fundamental nature of bone char and other solid adsorbents, and thus to indicate the direction for improvement, the Bureau has been conducting a long-range, cooperative research program under the sponsorship of the Bone Char Research Project, Inc.[1] This program, which was started by four refiners with the close cooperation of the late F. J. Bates, former chief of the Bureau's polarimetry group, was brought to the Bureau in 1939.[2] International interest and participation in the program, now under the direction of V. R. Deitz of the surface chemistry laboratory, has steadily increased until there are now 28 industrial supporters of the work—including sugar refiners and adsorbent manufacturers in Australia, Belgium, Brazil, Britain, Canada, France, the Netherlands, South Africa, and the United States.

Since the initiation of the bone char research program, several basic aspects of the adsorption process have been analyzed and clarified. At the same time, the investigations have been sufficiently general to cover the entire field of solid adsorbents and to touch upon many other pertinent areas. Bone char contains a carbonaceous fraction and an apatitic calcium phosphate fraction, both of which are important in other areas of research besides sugar refining. For example, investigations on the carbonaceous residue have applications ranging from granular carbon adsorbents to the graphite used in atomic reactors. The hydroxyapatite and its structure are studied by widely diverse groups in medicine and dentistry who are investigating bone and teeth structures, by geologists examining uranium deposits which tend to concentrate in similar structure, and by agriculturists developing fertilizers which are derived from phosphate rock.

The Char

Bone char may be classified as a mixed adsorbent. The carbonaceous residue, about 8 percent by weight,[3] contains in addition to carbon relatively large amounts of hydrogen, oxygen, sulfur, and nitrogen. The remaining fraction is chiefly calcium and phosphate, but contains smaller quantities of sodium, magnesium, sulfate, carbonate, and a dilute acid-insoluble ash. As

BONE CHAR

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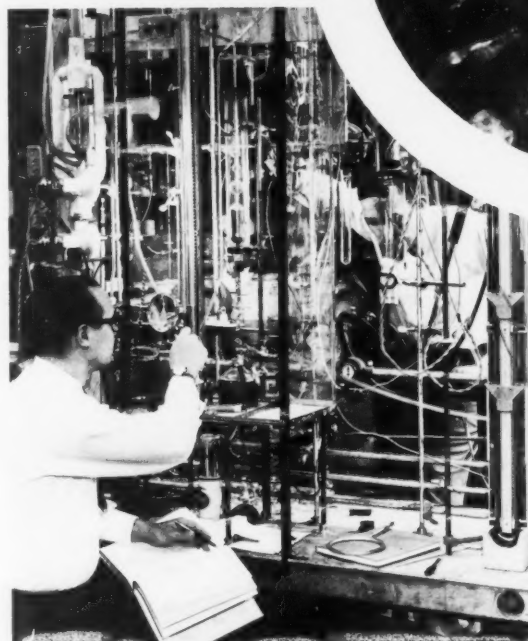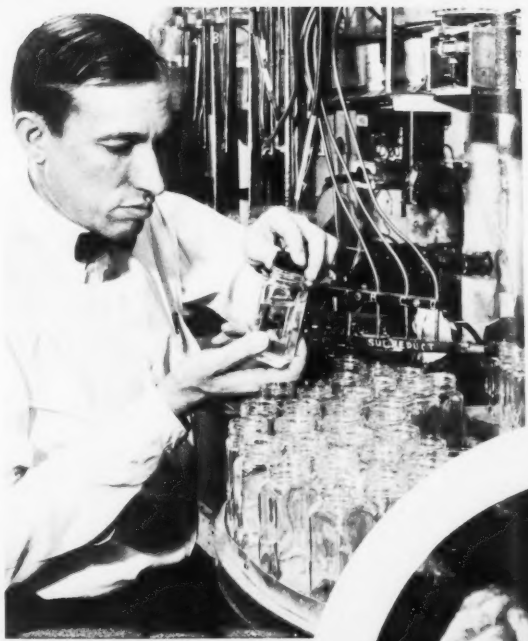
both fractions come from the original bone, they exist in a very intimate and closely joined mixture. Despite their widely different properties, they do not always react independently.

The surface area of bone char [4] was first investigated using a gas adsorption method at low temperatures. It was soon learned that the depurative properties of bone char depend on many other factors besides extent of surface, although this is one of the primary considerations. The porosity and the density did not correlate very well with the adsorption properties in solution systems.

The basic calcium phosphate fraction of bone char is one of the most insoluble substances known. Evidence has been obtained to indicate that some of the insolubility is due to a surface complex that completely covers the hydroxyapatite structure.[5] This surface complex is only one unit cell deep and is of a different composition than hydroxyapatite. Such behavior has fundamental implications in regard to calcification and "solubility" processes in basic calcium phosphates.

Physical Properties

Many tests have been developed at the Bureau for measuring various properties of bone char. Bone char is a very heterogeneous granular material and even the sampling has proven to be most critical.
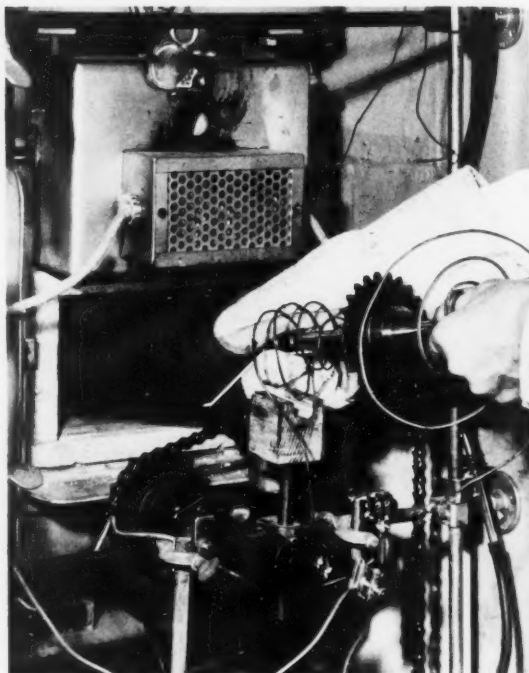
The attrition that bone char undergoes during its hundreds of cycles of use in sugar refining gradually decreases the particle size. The available testing sieves used for particle-size evaluation were critically examined, and a thorough study was made of the sieving process.[6] From this study, it was learned that the tolerances permitted in the openings of testing sieves were quite broad and that, if the size of the sieve openings was not uniform throughout, then the larger openings—rather than the average holes—controlled the passage of the particles. As a result, discrepancies were frequently found when sieve analyses from different laboratories were compared.

To eliminate this source of error, a sieve calibration method was developed which employs a mixture of glass spheres of graduated sizes. This procedure has now been adopted by the NBS length laboratory as a standard method of determining the effective opening of testing sieves.[7] In connection with this work, two

Center: Particles of revivified bone char ($\times 40$). The bonelike structure is evident after many cycles of use. Particles which have rounded edges have been utilized many times. *Upper right:* Char columns can be packed more reproducibly by first grading the particles according to size. This "stratified packing" is accomplished by sorting the char particles in a set (nest) of sieves, such as F. G. Carpenter places on the shaking machine. *Lower right:* Martha Peiperl closes the cooling plates on a high-voltage electrophoresis apparatus used to separate various ions present in sugar solutions. *Lower left:* Investigating the adsorption of carbon dioxide on bone char, Russell Arnold (*foreground*) measures the gas pressure, while Carpenter (*background*) adjusts the gas flow. *Upper left:* Carpenter examines a test fraction of sugar liquor which has been purified by bone char in the Bureau's laboratory-scale regenerating and adsorption system.

standard samples of graduated glass spheres have been prepared and are available from the Bureau.[8] With these standards of certified particle-size distribution, a uniform basis is provided for calibrating testing sieves.

The decrease in bulk volume caused by changes in the nestling together of different-sized particles (volume shrinkage) has been investigated. From this study a correlation was discovered between volume shrinkage and particle-size distribution. This relationship may have considerable significance to the general problem of flow through packings of granular materials.[9]

An improved test has been developed for studying the abrasion hardness of bone char. In this test a sample of the char is mechanically stirred in a specified [10] manner so that the abrading actions are similar to those encountered in commercial operations. The results are expressed in terms of the percentage reduction in particle size and the percentage dust formation (through No. 70 sieve). In general, this attrition hardness test is suitable for almost any granular solid, although it was designed specifically for bone char (see footnote 10).

Kilning of Bone Char

The key factor in the successful revivification of bone char is the kilning step. After bone char has been used for sugar-liquor purification, it goes through a four-step regeneration process.[11] First, water is introduced to the cisterns to displace the bulk of the remaining sugar. Second, the char is washed for as long as two days with enormous quantities of water. After this, it is dried and then finally heat-treated in the absence of oxygen in a kiln operating in the range 500 to 600 °C. This heat treatment has been carefully studied by the Bureau. The organic materials are pyrolyzed and the inorganic salts—especially calcium salts—which are not washed out or decomposed in the kilning gradually accumulate in the char through many regeneration cycles. This accumulation increases the crystallite size of the hydroxyapatite so that the bulk density may attain a value twice that of new char.

The mechanism by which the adsorbed calcium is incorporated into the char structure during kilning seems to involve two fundamental factors.[12] First, during the adsorption and desorption processes taking place in solution phase, there is a flux of calcium into the structure which is accompanied by a dynamic exchange among all ions at the boundary surface. This exchange results in a more stable arrangement—i.e., it leads to crystallite growth within the apatitic structure. Second, during the subsequent kilning there is a migration of calcium ions from the surface into the structure of the solid. A kinetic study indicates that the migration takes place with an activation energy of about 25 kcal. Kilning experiments with commercial and laboratory-prepared samples of hydroxyapatite—one of the char's main constituents—have paralleled studies with bone char.[13]

If for some reason the char is kilned at too low a temperature, its adsorptive capacity will gradually deteriorate. However, the Bureau has found that a few cycles of proper reburning will overcome the damage caused by inferior kilning.

Excess carbon—obtained from pyrolysis of adsorbed organic matter—tends to accumulate in bone char as it does in all thermally actuated adsorbents and catalysts. Because the carbon in bone char must be maintained at an approximately constant level for maximum effectiveness, this extra carbon must be removed. As the means commonly employed for decarbonization is oxidation, the reactions of bone char with oxygen have been studied in some detail.[14, 15] The criteria for uniform decarbonization are long reaction time, low temperature, and the appropriate concentration of oxygen. Unfortunately, these conditions are not always compatible with practical requirements.

Oxygen reacts with bone char, even at low temperature, to form a chemisorbed carbon-oxygen complex.[16] Evidence has been obtained to show that chemisorbed oxygen is essential to the decolorization of sugar liquors.

Sulfate, adsorbed by bone char from sugar liquors, also enters into the chemical reactions during kilning.[17]
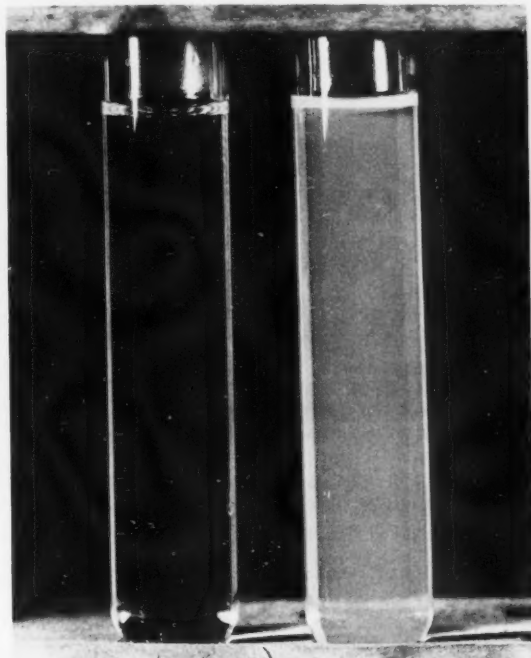
Above: Turbidity in sugar liquors is experimental evidence of the presence of suspended solids. However, some contaminants have the same refractive index as the sugar solution, so that the turbidity is masked. This is illustrated by the two test tubes, both of which contain the same amount of silica. The liquid on the left is a 65 percent sucrose solution (which has the same refractive index as silica), whereas the liquid on the right is water (which has a different refractive index). *Right:* Light-scattering pattern (scattering envelope) of a refined sugar compared with that of molecular sucrose. Light scattering is a sensitive measure of nonsucrose constituents. In the bottom panel, the scale is changed 100-fold to illustrate the large forward scattering of refined sugar.

The close intermixing of the carbonaceous and the hydroxyapatite fractions of bone char facilitates sulfate reduction to sulfide at the maximum kilning temperatures (500 to 540 °C). However, during the cooling process which follows kilning of actual bone char, the sulfate reduction is masked by surface oxidation. The existence of the sulfide cannot be determined by a surface reaction, but it can be detected by dissolving the char in strong acids.[18] The chemical reduction of adsorbed sulfate takes place several hundred degrees below that occurring in mechanical mixtures of calcium sulfate with charcoal. This is typical of the increased chemical reactivity at interfaces. As yet, it is not known what percentage of this increase is due to the intimate mixture of reactants and what percentage to a different state of reactivity at the interfaces.

Nonsucrose Constituents in Sugar Liquors

To evaluate the effectiveness of bone char as an adsorbent, it was necessary to develop criteria for judging various properties of sugar solutions, and the Bureau has made extensive studies in this area. Recently, the trend in commerce toward sugars in liquid form has placed increased emphasis on those visual properties of sugar solutions that indicate the degree of purity.

The visual properties, color and turbidity—more noticeable in sugar liquors than in crystal sugars—are experimental evidence of the presence of dissolved impurities (colorant) and suspended solids (turbidity).
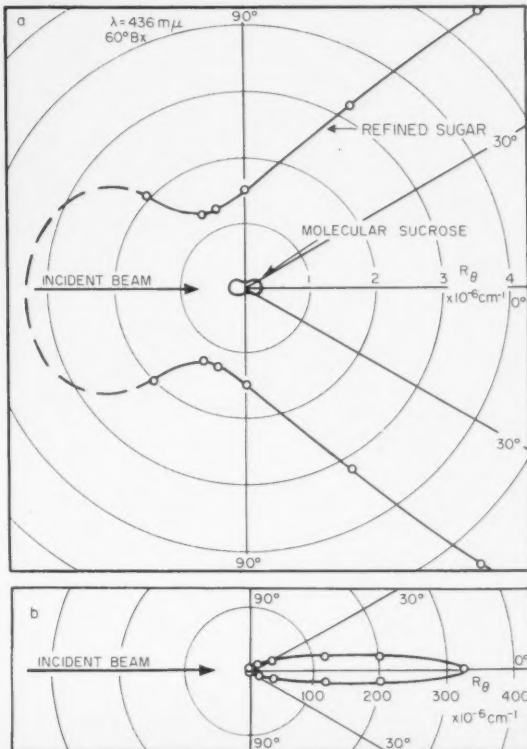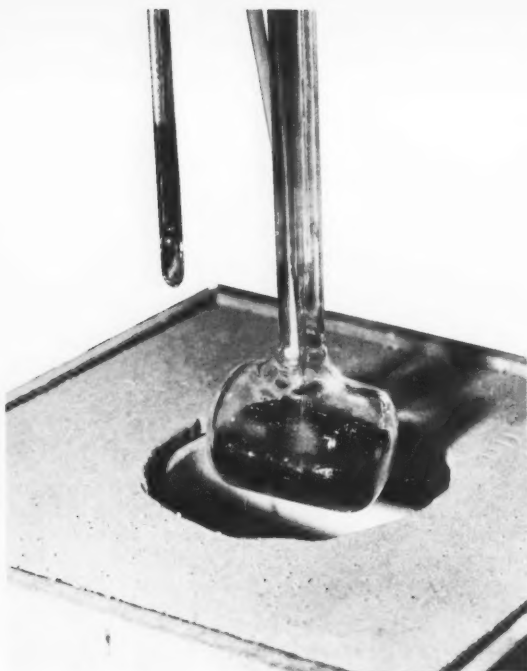
As another part of fundamental adsorption studies, graphite flakes in a Vycor tube are removed from a furnace (600 °C) prior to immersion in liquid oxygen (−183 °C). From measurements of adsorption isotherms at low temperatures and pressures, an evaluation of the heterogeneity of the surface can be made.

However, it is important to recognize that dissolved impurities with no color, suspended matter with no turbidity, or suspended matter with both color and turbidity can be present in solutions. As long as all of the various colored and turbid impurities present in the liquor were considered together as "color," a general theory of color removal by bone char, or any other adsorbent, could not be developed. Because the action of the bone char is to remove the impurities which cause these properties, it was necessary to study the measurement of color and turbidity—both separately and grouped together under the term attenuancy.

Historically the primary judgment of sugar impurity has been the level of its brownish amber color. As early as 1927 the Bureau [19] worked on the fundamental spectrophotometric aspects of the color problem. The goal of this work was to determine accurately the transmittances at specified wavelengths for a large variety of sugar products. The optical evaluation must differentiate between a transmittancy reading of an instrument and the appearance of the sugar color to the eye. With these factors in mind, the Bureau established a color scale for sugar solutions [20] based on the fundamental investigations of D. B. Judd of the Bureau staff. By using this scale the perceptible differences between the color of a commercial sugar and that of a highly purified sucrose solution were evaluated. Recently, this procedure was extended to include such dark-colored products as maple sugar and honey.[21]

The method expresses the visual appearance of sugar liquors on a scale evaluated from the primary spectrophotometric data. To characterize a commercial sugar, a solution is placed in a spectrophotometer for transmittancy measurements. From the transmittances of the solution at two specific wavelengths, a simple chart may be used to give the solution's visual color directly in NBS units. The development of this standard scale of sugar color has made it possible to evaluate objectively the visual appearance of liquid sugar products and has thus eliminated human error.

Light scattering, a very sensitive measure of colloidal impurities, greatly influences the visual appearance of liquids containing sugar. Although commercial sugar solutions have long been recognized as having low-level turbidity, a thorough study of their light-scattering behavior had never been conducted. When the scattered light was measured directly [22] with a modified commercial microphotometer, commercial sugar solutions were found to disperse light waves predominantly in the forward direction. The turbidity can be obtained by integrating the observed scattering over all angles.

Light-scattering measurements can be made independently of any absorption of light by color bodies whereas transmission measurements always include the effects of both absorption and scattering. Therefore, the effects of color and turbidity can be separated optically, without mechanical filtration or physical separation of the two types of impurities. Thus, by obtaining both scattering and transmission data, attenuancy [23] can be resolved into its components, absorption and scattering.

Sugar—like many organic compounds—is unstable. It is more unstable when hot and when in water solution. Because the refining of sugar is always done in hot solutions, the whole process can be considered as working against definite odds. In examining the thermal stability of sugar solutions, the Bureau found that some impurities seemed to inhibit degradation, whereas the degradation products themselves were autocatalytic. Some of the degradation products have been shown to be organic anions.

Inorganic Constituents

For many years, the sugar industry has treated the inorganic constituents of sugar as a single entity and has reported the results as total ash. However, work at the Bureau has shown that a total-ash determination is not adequate for following the changes in the bone char process. Compensating changes can occur that would make such a determination worthless. Thus, analysis of all the major constituents of the ash is essential for basic research as all the impurities (i.e., nonsucrose constituents) not only interact during the adsorption process but also their presence modifies the sugar crystallization process and thus affects the ulti-

mate purification of the final product. Furthermore, all inorganic ions present in a sugar liquor must be identified to understand such solution behavior as pH changes. If the pH is too low (acidic) during the sugar refining process, some sugar will be destroyed by hydrolysis; if it is too high (basic), some sugar will be lost by alkaline degradation. Bone char, besides eliminating color and ash, helps to maintain an approximately constant pH.

Suitable methods [24] have been developed for determining minute amounts of calcium, magnesium, chloride, sulfate, sodium, potassium, silica, and phosphate.[25] The difficulty is the interference of sucrose; many of the available microanalytical methods are not effective in the presence of large amounts of sucrose.

Instead of "ash" as weight percent, the total ionic content, either as total anions or total cations, has been suggested [26] as a more meaningful substitute. This measurement correlates well with "ash" and presents the possibility of a more useful interpretation.

Bone Char Process

In order to study better the bone char adsorption process in sugar refining, a laboratory-scale regenerating and adsorption system was devised at the Bureau.[27] In this system, the char is used to decolorize a raw sugar solution and is then passed through a revivification system of washing and kilning. All the conditions and flow rates can be carefully controlled. The treatment with the test sugar liquor serves two purposes: (1) it measures the influences of the previous kilning, and (2) it forms a spent char which can be subjected to a subsequent kilning operation. The testing procedure, which is completely mechanized, has demonstrated that about five complete cycles are required to establish the effect of a new set of conditions.

When impurities from liquids (e.g., sugar liquors) are adsorbed by granular solids in beds, obtaining uniform flow throughout becomes a problem. A careful study indicated that uniformity of particle-size distribution is a determining factor. Thus, to attain uniform flow in the laboratory system—and, in addition, almost total utilization of the char particles—the char was first sieved according to particle size and then the bed was packed in strata of the same particle size. With this arrangement, uniform flow, and thus highly reproducible results, were achieved.

In kilning, variation in temperature, oxygen concentration, rate of heating, and duration of treatment all affect the char's efficiency. To determine which parameters are the most important, and to test some of the large number of possible combinations, various statistical designs are used in planning experiments.

A surprisingly large amount of material goes in and out of the char structure during its many cycles of operation. To identify which substances actually remain on the char structure, Bureau scientists utilized radioactive tracers to differentiate between the calcium in the bone char adsorbent and the calcium in the material being purified.[28] The results indicated an extensive exchange of calcium ions in the solution with the calcium of the char.

In the washing phase of revivification, it has been found that more material can be washed out with cold water than with hot water. This is because calcium salts, which are the primary compounds desorbed during the washing, have greater solubility in cold water.

As a general adsorbent, bone char not only adsorbs impurities but also sucrose. It had long been supposed that all the sucrose was desorbed in the washing which is the first part of the revivification. However, studies using a pyrolysis technique and gas chromatography to analyze evolved gases have indicated that sucrose in the amount of a few tenths of one percent by weight of the char is permanently adsorbed by the char.[29] No amount of washing can remove this sucrose.

Bone char's adsorption of the various ions was found to be a very complex function of all the ions together. Monovalent ions are hardly adsorbed whereas polyvalent ions, including colorant anions, are strongly adsorbed. Thus, the color removal is dependent upon the ionic balance. The key ions which most influence the performance of char with a particular sugar liquor are calcium and sulfate.

[1] *Two comprehensive bibliographies on adsorbents and adsorption have been published. These contain a total of over 20,000 abstracts:* Bibliography of Solid Adsorbents, 1900 to 1942 (876 pp.), *V. R. Deitz. Copies may be procured from the Bone Char Research Project, Inc., c/o Revere Sugar Refinery, 333 Medford Street, Charlestown 29, Mass. ($12 prepaid)* ; and Bibliography of Solid Adsorbents, 1943 to 1953 (1528 pp.), *V. R. Deitz, NBS Circ. 566. Order from U.S. Government Printing Office, Washington 25, D.C. ($8.75).*

*To exchange data and to keep scientists informed about progress in bone char research technical sessions have been held every two years for sugar chemists from all over the world. The publications of these sessions—*Proceedings of the Technical Session on Bone Char—*have been issued after each conference since 1949. They may be obtained from the Bone Char Research Project, Inc., c/o Revere Sugar Refinery, 333 Medford Street, Charlestown 29, Mass.*

[2] Bone char research at the National Bureau of Standards, *NBS Tech. News Bull.* **32**, 39 (*Apr. 1948*).

[3] Determination of carbon and hydrogen in bone black and other chars, *V. R. Deitz and L. F. Gleysteen, J. Research NBS* **28**, 795 (1942) RP1479.

[4] Surface available to nitrogen on bone black and other carbonaceous adsorbents, *V. R. Deitz and L. F. Gleysteen, J. Research NBS* **29**, 191 (1942) RP1496; Adsorption of nitrogen on carbon adsorbents at low pressures between 69 and 90°K, *J. deD. Lopez-Gonzales, F. G. Carpenter, and V. R. Deitz, J. Research NBS* **55**, 11 (1955) RP2600.

[5] Solubility product phenomena in hydroxyapatite-water systems, *H. M. Rootare, V. R. Deitz, and F. G. Carpenter, J. Colloid Sci.* **17**, 179 (1962).

[6] New calibration method for testing sieves, *NBS Tech. News Bull.* **35**, 135 (1951); Methods of sieve analysis with particular reference to bone char, *F. G. Carpenter and V. R. Deitz, J. Research NBS* **45**, 328 (1950) RP2143.

[7] Glass spheres for the measurement of the effective opening of testing sieves, *F. G. Carpenter and V. R. Deitz, J. Research NBS* **47**, 139 (1951) RP2238.

[8] Standard samples of glass spheres for calibrating sieves, *NBS Tech. News Bull.* **43**, 148 (1959). The samples may be obtained from the Supply Division, Na-

tional Bureau of Standards, Washington 25, D.C. Over 600 different standard materials of chemicals, ores, ceramics, metals, and other substances are distributed by the National Bureau of Standards. Information is contained in Standard Materials, NBS Misc. Publ. 241, which may be obtained from the Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C. (30 cents).

[9] A review of pressure drop across columns of bone char, F. G. Carpenter, Intern. Sugar J., p. 12 (1955).

[10] Development of a new test for the abrasion hardness of bone char, F. G. Carpenter, Proc. Tech. Sess. Bone Char 1957, 99.

[11] Survey of Bone Char Revivification and Filtration, V. R. Deitz, 301 pp. (1947).

[12] Mechanisms of color and ash removal by bone char, A. Gee, Proc. Tech. Sess. Bone Char 1957, 163.

[13] Pyrophosphate formation upon ignition of precipitated basic calcium phosphates, A. Gee and V. R. Deitz, J. Am. Chem. Soc. 77, 2961 (1955).

[14] Fundamental aspects of the reaction of oxygen with carbon adsorbents, W. V. Loebenstein and N. L. Pennington, J. Research NBS 43, 87 (1949) RP2009.

[15] Kinetic study of the reaction of carbon adsorbents with oxygen, W. V. Loebenstein, L. F. Gleysteen, and V. R. Deitz, J. Research NBS 42, 33 (1949) RP1948.

[16] Oxygen chemisorption on carbon adsorbents, W. V. Loebenstein and V. R. Deitz, J. Phys. Chem. 59, 481 (1955).

[17] Sulfur in bone char, L. P. Domingues, Proc. Tech. Sess. Bone Char 1953, 307.

[18] Determination of sulfur in bone char, V. R. Deitz, H. R. Higginson, and C. Parker, J. Research NBS 40, 263 (1948) RP1871.

[19] Color in the sugar industry. I. Color nomenclature in the sugar industry. II. Colorimetric clarification of turbid sugar solutions, H. H. Peters and F. P. Phelps, Tech. Pap. BS No. 338 (1927).

[20] Color evaluation in the cane sugar industry, V. R. Deitz, J. Research NBS 57, 159 (1956) RP2706; Color and turbidity of sugar products, R. W. Liggett and V. R. Deitz, Advances in Carbohydrate Chem. 9, 247 (1954).

[21] Glass color standards and a uniform chromaticity scale for sugar products, B. A. Brice, J. Opt. Soc. Am. 50, 49 (1960).

[22] Light scattering by commercial sugar solutions, C. J. Rieger, and F. G. Carpenter, J. Research NBS 63A, (Phys. and Chem.), 205 (1959).

[23] Transmittancy of commercial sugar liquors: Dependence on concentration of total solids, V. R. Deitz, N. L. Pennington, and H. L. Hoffman, Jr., J. Research NBS 49, 365 (1952) RP2373.

[24] Determinations of inorganic constituents in sucrose solutions, A. Gee, L. P. Domingues, and V. R. Deitz, Anal. Chem. 26, 1487 (1954).

[25] Determination of phosphate by differential spectrophotometry, A. Gee and V. R. Deitz, Anal. Chem. 25, 1320 (1953).

[26] Determination of total cations in commercial sugars, L. P. Domingues, Proc. Tech. Sess. Bone Char 1955, 347.

[27] A study of the chemical reactions in kilning bone char, F. G. Carpenter and V. R. Deitz, Proc. Tech. Sess. Bone Char 1959, 321.

[28] Experiments on the removal of ash constituents with bone char, A. Gee, Proc. Tech. Sess. Bone Char 1955, 357.

[29] Sugar retention by char, F. G. Carpenter, Proc. Tech. Sess. Bone Char 1957, 279.

Symposium on

Optical Character Recognition

Robert Herbold (left) inspects computer print-out as Kermit Nelson watches. The computer is being used to compute the "moments" about the centers of gravity of printed characters in a study of pattern recognition.

MORE THAN 800 computer scientists and users from the United States and abroad attended a Symposium on Optical Character Recognition held January 15, 16, and 17 at Washington, D.C., under the joint sponsorship of the Bureau and the Office of Naval Research. Plans for the Symposium were made by a conference committee consisting of Donald K. Pollock of ONR, Bernard Radak of Navy Bureau of Supplies and Accounts, and Mary Elizabeth Stevens of NBS. Twenty-two papers on optical character recognition systems, both operative and in research, were given in two sessions, followed by a panel discussion of user requirements for new systems and another on the horizons of optical character recognition work.

Many experts believe that the next great step forward in automatic data processing will come through the development of techniques for automatic character recognition. Data processing systems in use today require as inputs information that has been carefully translated into the machine's language and encoded in a suitable medium. Only a few systems will accept information not already coded on cards or tape. One such system, FOSDIC, developed by NBS for the Bureau of the Census, uses optical sensing of response placement in a format designed to be self-coding. Another type of machine identifies documents by magnetically scanning areas of numerals printed in a specially designed typeface and with magnetic ink. Present-day devices, a few in operation and others

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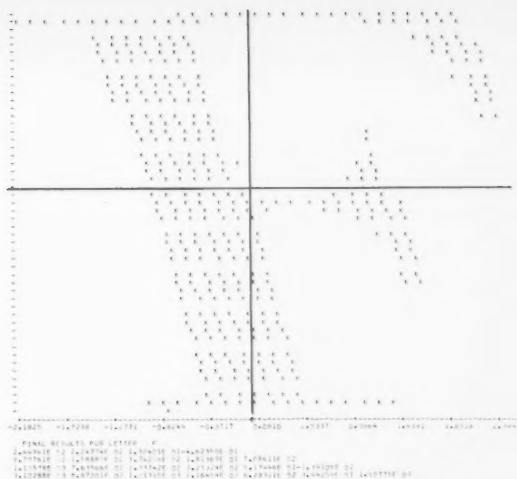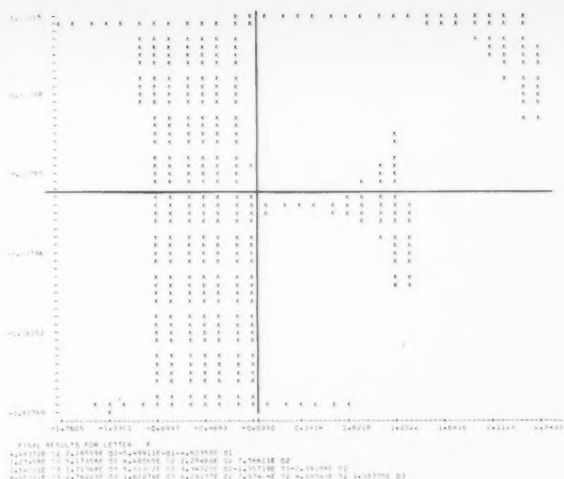
Computer print-out of machine computation of the moments of printed characters includes the characters themselves—here two versions of the capital F; deviations from the center of gravity along the X and Y scales; and, at the bottom, the computed moments about the center of gravity. The lines crossing near the middle of each F locate its center of gravity. The moments are used to identify characters.

under development, can read one or a few fonts of typed or printed material. However, no reading machines with true multifont recognition capabilities are as yet in productive operation, and no devices are as yet available which can read handwritten material with the degree of success that would be accepted in many tasks as a reasonable substitute for the human reader.

Today's data processing systems would be much more useful if they could accept a variety of printed, written, or graphic data as inputs. The Symposium was arranged so that investigators working toward this end might benefit from knowledge of developments and findings in other laboratories. In addition, potential users were invited to attend to permit an interchange of information with respect both to requirements and to present-day capabilities. The information thus shared should facilitate development of new methods of optical character recognition and speed the day when more flexible input systems will become available for data processing.

The Symposium was divided into two one-day and two half-day sessions. The first session featured talks on the characteristics of operative character recognition systems, given by people involved in developing them. The second session explored the trends in present character recognition research, while the third and fourth presented panel discussions on user requirements and the prospects for the future. The proceedings of the Symposium will be published in book form by Spartan Books, becoming available about September 1962.

The Symposium opened with a welcoming address by M. C. Yovits of the Office of Naval Research. The first session consisted of talks, under the chairmanship of D. K. Pollock of the Office of Naval Research, de-

scribing character recognition systems now in operation or being prepared for delivery in the near future. The first paper was by W. T. Hannan of Applied Research, Defense Electronics Products, RCA. He described the RCA multifont reading machine which uses interchangeable photographic matrix masks as reference patterns, accomplishes the recognition decisions by means of optical correlation techniques, and incorporates automatic line and character location features in the electronic scanning system. A reading rate of 500 characters per second at accuracies of 1 to 5 errors per million characters was reported for this machine. Potential applications to the reading of printed pages, including Cyrillic texts, were discussed.

G. L. Fischer and C. C. Heasly, Jr., of Farrington Electronics were the coauthors of a paper discussing optical scanning requirements with special reference to automatic input systems for a variety of applications. A new model Farrington reader, the Selected Data Page Scanner, was announced in a press release coinciding with the opening of the Symposium. The new reader incorporates interchangeable plugboard-programing format-control features to facilitate line location and field location within a line and to accommodate various word length and storage mode conditions.

Following this paper, J. Rabinow described the several approaches to automatic character recognition that have been investigated by the Rabinow Engineering Company, Inc. Readers using varied techniques, including optical-mask coincidence correlation, weighted area matrix correlation, and multiple nonre-entrant curve tracing, were discussed. It was concluded that anything now typed or printed can be read by machine and that within 5 to 10 years cursive handwriting should be machine readable.

J. B. Chatten and C. F. Teacher of the Philco Research Center next described the use of high-resolution flying spot-scan techniques in a variable-font address reader being developed for the Post Office Department. Features include automatic character location, means to normalize the size of unknown characters, following of lines regardless of tilt, and provisions for rescanning to resolve ambiguity on a character-by-character basis. Recognition decisions in the Philco reader are based on shift-register correlations where the unknown pattern is compared with a number of weighted area reference patterns stored in the form of resistor arrays.

The principles of operation of a page-reader for Cyrillic text, under development by Baird-Atomic, Inc., were presented by J. A. Fitzmaurice. This reader uses an optical correlation technique for character recognition at rates up to 1,000 characters per second. Input is in the form of microfilm copies of pages of printed Russian language material. Problems of handling special symbols, equations, and other interspersed graphic material were discussed.

The advantages of vidicon scanning techniques in character recognition systems using an area analysis principle were discussed by P. Barth of the National Data Processing Corporation, a Division of Remington Rand UNIVAC. He described results of this technique as giving recognition rates of up to 1,000 characters per second for 20-μsec exposures of the source documents.

Leon Mintz described the typed page reader developed for the Army Signal Corps by the Control Instrument Division of Burroughs Corporation. This equipment was designed to read upper- and lower-case alphanumeric characters in standard elite type font. The device reads typed pages stacked in its input hopper and converts the characters into teletype code at a rate of 75 characters per second. Line tilt of as much as 10° can be accommodated without loss of reading accuracy.

A numeric character reader that will accept wide tolerances in quality of printing was described by R. K. Gerlach of the Electronics Division of the National Cash Register Company. The NCR equipment was designed for use with a special font; source documents consist of paper strips imprinted by various accounting and cash register machines. Reject rates of the order of 10^{-4} and error rates of 10^{-6} were reported for this equipment.

A paper by W. T. Booth, G. M. Miller, and O. A. Schleich described character recognition developments at the General Electric Company. A recently developed machine has been designed to read the numeric font under consideration by the X3.1 Subcommittee of the American Standards Association. Several recognition logics for reading at rates up to 2,500 characters per second were described. Problems in reading misregistered and degraded characters were discussed.

The first day's session was concluded by E. C. Greanias of the Advanced Systems Development Division, IBM, who discussed various factors which affect the realization of practical character recognition devices. The nature of the documents to be read, the administrative control that can be exercised in document preparation, the costs of handling rejects, were discussed in terms of determination of economic feasibility. The progress made in the development of methods of pattern analysis was noted. The recognition logic, testing procedures, and printer evaluation studies used in the development of the IBM 1418 reader were described.

The second day's session was devoted to trends in character recognition research. The first speaker was A. B. Novikoff of the Mathematical Sciences Department, Stanford Research Institute. He discussed the need for a usable mathematical model for "geometric noise" which results from random disturbances of a pattern from its ideal representation. General requirements which such a model should satisfy and the example of a particular proposed model were described.

A system for reading cursive handwriting was described by L. D. Harmon of the Bell Telephone Laboratories. Two distinct problems are involved: The segmentation of the handwritten word into its component characters and the recognition of the script letters themselves. A system involving the use of local, criterial features has been developed and tested on sentences written with a special stylus under the constraints of observing base and guide lines. An accuracy of 90 percent was achieved with a number of samples from different writers. The use of confusion matrix statistics and diagram probabilities to improve performance was described.

The comparison of computed moments of input character patterns with the corresponding moments of prototype patterns was described by F. L. Alt of the National Bureau of Standards. He pointed out that certain combinations of moments are relatively invariant for pattern transformations such as size, translation, and some slanting. Experiments on a computer indicate that a process using a modest number of sample points and computing moments only up to the sixth order is adequate to discriminate between the characters of a given alphabet. The general problem of classifying items characterized by a set of numbers was discussed.

The next paper, by R. F. Meyers, V. E. Giuliano, and P. E. Jones of Arthur D. Little, Inc., similarly postulated sets of mathematical derivatives of certain integral measurements of character patterns. It was noted that methods based on measurements of a number of moments or a number of Fourier coefficients offer means to normalize by computing a set of invariants with respect to frequently encountered pattern transformations, such as translation or scaling. A procedure was described for obtaining a set of measurement functions which minimize the error rate for a given alphabet and a given degree of noise.

D. M. Baumann of the Massachusetts Institute of Technology described preliminary results of a study of the use of area weighting techniques for automatic character recognition. Input character patterns were categorized into subsets on the basis of optical sensing through a sequence of photographic masks. Mask design was based upon statistical parameters of a set of

characters and weighting functions chosen to provide optimal separation.

A paper by L. G. Roberts reviewed character and pattern recognition developments at the Massachusetts Institute of Technology during the past five years. It was noted that earlier research on hand-printed characters was followed by studies on cursive handwriting and that progress has been made in characterizing handwritten strokes.

Continuing pattern recognition research in the general Perceptron research program was reported in a paper by W. S. Holmes, H. R. Leland, and J. L. Muerle of the Cornell Aeronautical Laboratory. In particular, a multi-layered Perceptron system has been simulated by computer to investigate the feasibility of training the system to recognize mixed font alphanumeric characters. The input pattern is prefiltered to provide a transformed image space, combinations of intensities at selected points in the transformed image space are used as properties, and a linear discriminant function is applied to classify the pattern.

A scheme for recognizing patterns from an unspecified class was described by C. Barus of Swarthmore College. Small subsets of specimens of each of the patterns to be recognized are stored in the machine. The information contents of these subsets change during a learning phase to become more typical of the pattern represented. Possibilities for implementation by optical comparisons were discussed.

In a paper by W. H. Highleyman of the Bell Telephone Laboratories, a distinction was made between the "receptor" and the "categorizer" operations of a pattern recognition system. The categorizer typically determines, from measurements made by the receptor on an unknown pattern, the particular pattern class to which the unknown belongs. The paper considered in detail that class of categorizers involving the linear decision functions. In connection with the problem of recognizing hand-printed numeric characters, procedures were illustrated based upon sampling from pattern classes to be identified for choice of linear decision function.

Techniques for multifont print recognition were described by M. C. Andrews of the Thomas J. Watson Research Laboratory of IBM. Problems encountered and experimental techniques which offer apparently promising solutions were discussed. The speaker also described automatic error detection and corrections

methods applicable to systems which are required to accept and process natural language text.

M. B. Clowes of the National Physical Laboratory, Teddington, England, described a method for character recognition involving one or more autocorrelation functions of an unknown pattern. The form of the autocorrelation function specifies a character feature, such as a straight line or a "hook." Such functions are invariant with respect to transformations of size, rotation, and translation and are relatively insensitive to minor changes in style or printing quality.

L. Uhr of the University of Michigan presented a paper, prepared by himself and C. Vossler of the Systems Development Corporation, reviewing current trends in the "search to recognize." He noted the specific problems to be solved, the array differing with selections of font and vocabulary size, method of presentation, and method of recognition. It was also noted that, on the other hand, general methods for pattern recognition would allow for common solutions to families of problems. He then described a specific experimental technique which enables an adaptive categorization of information-carrying features of unknown inputs. Results were given for subsequent recognition both of hand-drawn alphanumeric characters and of certain outline drawings, including comic-strip faces.

The third session of the symposium consisted of a description and panel discussion of representative user requirements in various government agencies. The panel was under the chairmanship of B. Radack, Bureau of Supplies and Accounts, Navy, and was composed of G. Shiner, Rome Air Development Center; C. Sparks, U.S. Civil Service Commission; P. Howerton, Central Intelligence Agency; Major L. Sears, Army Finance Office; R. Hessinger, Post Office Department; and W. Velander, Navy Management Office.

The fourth and final session was held Wednesday afternoon, January 17, under the chairmanship of M. C. Yovits of the Office of Naval Research. This session was opened by a keynote address by O. G. Selfridge of the Massachusetts Institute of Technology. The following panel discussion brought forth remarks on the horizons for optical character recognition research by J. D. Noe, Stanford Research Institute; J. C. R. Licklider, Bolt, Baranek and Newman; H. A. Affel, Jr., Auerbach Corporation; D. H. Shepard, Cognitronics; D. Brick, Sylvania; and J. J. Eachus, Minneapolis-Honeywell.

Publications of the National Bureau of Standards

Periodicals

Technical News Bulletin, Vol. 46, No. 6, June 1962. 15 cents. Annual subscription: $1.50, 75 cents additional for foreign mailing. Available on a 1-, 2-, or 3-year subscription basis.

Basic Radio Propagation Predictions for September 1962. Three months in advance. CRPL–214, issued June 1962. 15 cents. Annual subscription: $1.50, 50 cents additional for foreign mailing. Available on a 1-, 2-, or 3-year subscription basis.

Journal of Research of the National Bureau of Standards
  Section A. Physics and Chemistry. Issued six times a year. Annual subscription: Domestic, $4; foreign, $4.75.

  Section B. Mathematics and Mathematical Physics. Issued quarterly. Annual subscription: Domestic, $2.25; foreign $2.75.

  Section C. Engineering and Instrumentation. Issued quarterly. Annual subscription: Domestic, $2.25; foreign, $2.75.

  Section D. Radio Propagation. Issued six times a year. Annual subscription: Domestic, $4; foreign, $4.75.

Technical Notes

The following Technical Notes are available from the Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C. (order by PB number).

Publications (Continued)

Airborne television coverage in the presence of co-channel interference, M. T. Decker, NBS Tech. Note 134 (PB161635) (1962) $2.00.

Ionosonde observations of artificially produced electron clouds: Firefly 1960, J. W. Wright, NBS Tech. Note 135 (PB161636) (1962) $2.50.

Some problems of fatigue of bolts and bolted joints in aircraft applications, L. Mordfin, NBS Tech. Note 136 (PB161637) (1962) $1.25.

Mean electron density variations of the quiet ionosphere—September 1959. J. W. Wright, L. R. Wescott, and D. J. Brown, NBS Tech. Note 40–7 (PB151399-7) (1962) $1.50.

Mean electron density variations of the quiet ionosphere No. 13; Summary of one year of data, May 1959–April 1960, J. W. Wright, NBS Tech. Note 40–13 (PB151399-13) (1962) $1.50.

Bibliography on auroral radio wave propagation, W. Nupen, NBS Tech. Note 128 (PB161629) (1962) $2.75.

A bibliography of the thermophysical properties of oxygen at low temperatures, J. C. Hust, L. D. Wallace, J. A. Crim, L. A. Hall, and R. B. Stewart, NBS Tech. Note 137 (PB161638) (1962) $2.25.

Vertical cross sections of the ionosphere across the geomagnetic equator, J. W. Wright, NBS Tech. Note 138 (PB161639) (1962) $1.00.

Siting criteria for HF communication centers, W. F. Utlaut, NBS Tech. Note 139 (PB161640) (1962) $1.25.

Atlas of Fourier coefficients of diurnal variation of f_0F_2, W. B. Jones, NBS Tech. Note 142 (PB161643) (1962) $2.50.

Numerical results for the surface impedance of a stratified conductor, C. M. Jackson, J. R. Wait, and L. C. Walter, NBS Tech. Note 143 (PB161644) (1962) $1.25.

Cryogenic temperature measurement with platinum resistance thermometers—Is fixed-point calibration adequate? R. J. Corruccini, NBS Tech. Note 147 (PB161648) (1962) 50 cents.

Publications in Other Journals

Dissociation constant of 2-ammonium-2-methyl-1, 3-propanediol in water from 0 to 50° and related thermodynamic quantities, H. B. Hetzer and R. G. Bates, J. Phys. Chem. **66**, 308–311 (1962).

An introduction to flame photometry and a review of recent studies, M. Margoshes, Phys. Tech. Biological Research 4, 215–260 (1962).

Congruences for the partition function to composite moduli, M. Newman, Illinois J. Math. **6**, No. 1, 59–63 (Mar. 1962).

Research and the saving of teeth, G. C. Paffenbarger, J. Prosthetic Dentistry **12**, No. 2, 369–383 (Mar.–Apr. 1962).

Displacement and strain-energy distribution in a longitudinally vibrating cylindrical rod with a viscoelastic coating, P. Hertelendy, J. Appl. Mech. Trans. ASME **29**, Series E, No. 1, 47–52 (Mar. 1962).

Properties of silico-phosphate cements, J. N. Anderson and G. C. Paffenbarger, Dental Progress **2**, No. 2, 72–75 (Jan. 1962).

Comments on paper by W. D. Westfall, "Prediction of VLF diurnal phase changes and solar flare effect," J. R. Wait, J. Geophys. Research **67**, No. 2, 916–917 (Feb. 1962).

The shape of the geomagnetic field boundary under uniform external pressure, R. J. Slutz, J. Geophys. Research **67**, No. 2, 505–513 (Feb. 1962).

Plating standards and specifications, F. Ogburn, Electroplating Eng. Handb. 2d ed., Ed. K. Graham, Ch. 7, pp. 257–262 (Reinhold Publ. Co., New York, N.Y., 1962).

Surface effect on bond strength of steel beams embedded in concrete, J. O. Bryson and R. G. Mathey, J. Am. Concrete Inst. **59**, No. 3, 397–406 (Mar. 1962).

Inequalities for the permanent function, M. Marcus and M. Newman, Ann. Math. **75**, No. 1, 47–62 (Jan. 1962).

Study of electronically excited hydroxyl radicals in the $H + O_2$ atomic flame, H. P. Broida, J. Chem. Phys. **36**, No. 2, 444–448 (Jan. 1962).

Theory of thermal diffusion in dilute alloys, R. E. Howard and J. R. Manning, J. Chem. Phys. **36**, No. 4, 910–916 (Feb. 1962).

Effects of monomeric reagents on the melting (contraction) and recrystallization of fibrous proteins, L. Mandelkern, W. T. Meyer, and A. F. Diorio, J. Phys. Chem. **66**, 375–376 (1962).

A correction to the exospheric electron density estimate using the nose whistlers of March 19, 1959, J. H. Pope, J. Geophys. Research **67**, No. 1, 412 (Jan. 1962).

Hydrogen formation in the gamma-radiolysis of ethylene, P. Ausloos and R. Gorden, Jr., J. Chem. Phys. **36**, No. 1, 5–9 (Jan. 1962).

Investigation of the spectrophotometric method of measuring the ferric ion yield in the ferrous sulfate dosimeter, K. Scharf and R. M. Lee, Radiation Research **16**, No. 2, 115–124 (Feb. 1962).

Microwave spectrum and nonplanarity of cyanamide, D. J. Millen, G. Topping, and D. R. Lide, Jr., J. Mol. Spectroscopy **8**, No. 2, 153–163 (Feb. 1962).

Long-distance one-hop F_1 propagation through the auroral zone, L. H. Tveten, J. Geophys. Research **66**, No. 6, 1683–1684 (June 1961).

Impurity effects in high purity metal, L. L. Wyman and G. A. Moore, (Symp. Major Effects of Minor Constituents on the Properties of Materials. Sixty-fourth annual meeting ASTM, Atlantic City, N.J., June 26, 1961), ASTM Spec. Tech. Publ. No. 304—ASTM Material Sci. Series 2, 3–16 (June 26, 1961).

Preparation of and electroplating of uranium, D. E. Couch, Plating **49**, No. 4, 363–367 (Apr. 1962).

Vibration-rotation interactions in cyanamide; the question of planarity of amides, D. R. Lide, Jr., J. Mol. Spectroscopy **8**, No. 2, 142–152 (Feb. 1962).

Tensile strength and modulus of elasticity of tooth structure and several restorative materials, R. L. Bowen and M. S. Rodriguez, J. Am. Dental Assoc. **64**, No. 3, 378–387 (Mar. 1962).

Vacuum ultraviolet photochemistry. III. Primary processes in the vacuum ultraviolet photolysis of water and ammonia, J. R. McNesby, I. Tanaka, and H. Okabe, J. Chem. Phys. **36**, No. 3, 605–607 (Feb. 1962).

Accuracy of analytical procedures, W. J. Youden, J. Assoc. Official Agricultural Chemists **45**, No. 1, 160–173 (Feb. 1962).

Publications for which a price is indicated (except for Technical Notes) are available only from the Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C. (foreign postage, one-fourth additional). Reprints from outside journals and the NBS Journal of Research may often be obtained directly from the author.

The following U.S. Patents have recently been granted on NBS inventions and, except as noted, are assigned to the United States of America as represented by the Secretary of Commerce.

3,019,174   Jan. 30, 1962   Process for Electrowinning Titanium from Lower Valent Titanium Alkali Chlorides—Abner Brenner and Joseph M. Sherfey (Army).

3,020,963   Feb. 13, 1962   Cup Anemometer—William Hakkarinen (Navy).

3,022,182   Feb. 20, 1962   Infrared Transmitting Glasses—Given W. Cleek and Edgar H. Hamilton (Navy).

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